Landsat Data Continuity Mission Workshop

January 9-10, 2001

U.S. Geological Survey Auditorium
Reston, VA

Sponsored by the
U.S. Geological Survey and the
National Aeronautics and Space Administration

Prepared by David Fry, Consultant Writer, RS Information Systems, Inc.

Landsat Data Continuity Mission Workshop

Tuesday, January 9

Welcome and Introductory Remarks

Mr. Ray Byrnes opened the session by clarifying several logistical matters and by introducing Dr. Charles Groat, Director of the U.S. Geological Survey (USGS), who officially welcomed conference participants on behalf of his agency. Dr. Groat noted the USGS's 30-year involvement with satellite imaging, which ranges from early research and advocacy to operation, archiving, and distribution. The present represents a time of transition and creative opportunity, for a broad field of players, including data providers, value added resellers, consultants, and other commercial interests. The USGS will continue its traditional role of encouraging data utilization and working to protect the user community and the values inherent in the Landsat mission. Dr. Groat emphasized the agency's interest in global systems and suggested that Landsat 7 still played an irreplaceable role in this arena.

These opening remarks were followed by a brief address from Dr. Mary Cleave, representing the earth science community within the meeting's other cosponsor, the National Aeronautics and Space Administration (NASA). Dr. Cleave mentioned the overall importance of systematic measurements to her agency and the challenge of forging new partnerships with the private sector in this broad scientific pursuit. She also described the accelerating technical capabilities of the various Landsat instruments. Her concluding comments touched on the need to explore the best data purchase possible for program continuation.

Overviews

Mr. Byrnes. In the next portion of the program, Mr. Byrnes set the stage for the panel discussions to follow. He recalled how Congress in 1992 had passed legislation outlining four operational options for the Landsat missions: a fully privatized system, an international consortium, a Government-run program, and a public-private partnership. Although Congress had expressed a clear preference for the first option, experience with previous Landsats revealed that market demand was insufficient for such a strategy. The second option—an international consortium—isof great interest to USGS, but the timeframe for building and institutionalizing a complex entity like this extended beyond the near-term requirement for the Landsat Data Continuity Mission (LDCM). Because of little Congressional interest in a fully-taxpayer-supported program, the primary alternative at this point appears to be the fourth option—a Government-industry partnership.

To place Landsat within the larger spectrum of earth-observing satellites, Mr. Byrnes outlined three basic classes of missions. The first encompassed "public good" undertakings, such as the meteorological instruments flown by the National Oceanographic and Atmospheric Administration (NOAA), which are supported entirely

by the taxpayer. These serial (lower cost) endeavors generate data within the public domain that can also be repackaged by resellers. The second type, representing the other extreme, is typified by commercial high-resolution satellites funded through large private investments. The resulting data are sold or leased to government and commercial customers. On the middle ground fell the third kind of mission, such as Satellite pour l'Observation de la Terre (SPOT), in which publicly launched sensors collected data that are sold or leased to a broad range of customers.

Mr. Byrnes briefly discussed the Landsat series within this overall framework. While satellites 4 and 5 are flown by a private contractor under arrangements similar to SPOT, Landsat 7 more closely fist the public domain model. Even so, the relatively low cost of scenes produced by the current satellite ($600 each) can still be prohibitively expensive for both small-scale, occasional data users and scientists studying regional or global phenomena.

In concluding, Mr. Byrnes encouraged participants with views on the data specification and related issues to offer written comments on forms (at the registration desk) or on the LDCM Web site. He said that the workshop organizers were particularly interested in feedback on the appropriate level of funding and operational responsibility for Landsat 7 that should be born by the private sector. The conference cosponsors were likewise seeking to determine which data should be retained for the public domain and which might be available under commercial terms.

Dr. Wende. Representing NASA, Dr. Charles Wende filled in more of the background to the LDCM. He briefly traced the development of earth-observing satellites, from the initial launch in 1972 up to the present. Note was made of the commercialization of the program in 1985 and the restoration of it to the Government in 1992 legislation. This law committed the United States to continuity of Landsat type data, he said. After the failure of Landsat 6, the challenge of data continuity passed to Landsat 7. Authority for the Landsat program, originally shared by NASA with the Department of Defense (DOD), shifted to a NASA partnership with USGS. Recent years had also witnessed a change in user pricing structure, with scene costs dropping from approximately $4,400in the earlier years of Landsat commercialization to around $600 at present.

Focusing on the last 2 years, Dr. Wende described how various Landsat continuity options, including data buys and fixed-price contracts, had been explored through several channels. For example, last fall an internal Government workshop was held to exchange lessons-learned in data-buys, fixed-price contracts, etc. In late September, the draft data specification was approved for posting and comment on the Web. Earlier, the Government had issued a request for information (RFI) to survey industry's assessment of Landsat continuity opportunities. Most respondents indicated that there was no economically viable market for 30-meter data. No one was planning to build a system based on this level of resolution, even though contractor-owned and –operated hardware was the preferred industry approach to earth imaging. Another revelation during this exploratory phase was that prepayment for data dramatically reduced life cycle costs.

The agencies' approach to mission continuity now revolves around a number of points: only data, and not hardware, would be specified; Landsat quality data should become available through the LDCM by 2005-06; data would be the principal deliverable; NASA would share costs and risks, as well as new technology, with private partners; participating firms would have to demonstrate a business plan that included data rights; NASA and USGS would continue to validate the design, implementation, and data produced; and the Government would still be a major customer in a shared mission. These assorted requirements and opportunities were compatible with all four structural options already identified along the private-public spectrum, at least in the sense of providing the same type and quality of data to the broad community of users.

Dr. Wende concluded his presentation by previewing the day's agenda and outlining his expectations for the conference, including a frank discussion of the data specification and commercial opportunities. He emphasized the need for a wide range of input from data providers, users, resellers, and distributors, who were all represented at the workshop. Their feedback would be incorporated into workshop and panel discussion summaries that would eventually be posted on the Web. Detailed, written comments on the data specification would also be welcome, especially via e-mail. Respondents could comment or query up to within a few days of the procurement announcement.

During the discussion that followed, Dr. Wende clarified the scope and timeframe of the LDCM. The RFP was expected to ask for 5 years' worth of data with the option for an additional 5 years' supply. A draft RFP would be released by late spring or summer of 2001, with the final version probably to be issued in the fall. When asked about anticipated agency response to a lack of commercial interest in the procurement, he suggested that the greater earth science community, including the Government itself, would not let Landsat die in the absence of comparable technology. Dr. Wende emphasized the array of opportunities for companies to continue Landsat such as in tandem with other instruments, or by combining higher-resolution data, (spectral and/or spatial), etc. As long as NASA and USGS received their specified products, partners could use whatever means or add-ons they wanted.

Mr. Byrnes addressed a final question about the international consortium option. Although USGS had great interest in developing global data sets and enlarging the network of ground stations around the world, the international space agencies were not yet officially engaged in the LDCM dialog. Because discussions on the international level were still preliminary, the successor to Landsat 7, at least in the short term, depends on an American solution.

Dr. Irons. After expressing his appreciation for the broad-based turnout for the day's workshop, Dr. James Irons described his role as Deputy Landsat Project Scientist in the development of the data specification for the LDCM. He noted how the process had begun with the approval of the project by NASA's Associate Administrator of the Earth Science Enterprise in October 1999. Shortly afterward, a working group was formed that drew from various NASA centers, USGS, and MIT Lincoln Laboratory. By spring a first draft of the specification was complete, and after internal agency review, it was posted on

the Web (http://ldcm.usgs.gov)for public review and comment on November 6, 2000. The working group will soon reconvene to review the public comments from the Web site and the present workshop, as well as from the science team. He stressed that the current data specification was not the RFP; that would come later.

Development of the specification had proceeded so as to be consistent with legislation limiting the Government's role in Landsat imaging to data preprocessing—i.e., registration to the Earth's surface features and calibration of spectral response. The working group had avoided specifying particular technologies. Dr. Irons reiterated Dr. Wende's earlier assertion that the data specification was not a design document. Rather, it was an assessment of end-to-end system requirements, including the quantity, characteristics, and quality of unenhanced data products.

The basic premise of the LDCM, Dr. Irons continued, was to fulfill the goals of the 1992 Remote Sensing Policy Act, including education, global change research, and natural resource management. To accomplish these, it would be necessary for the follow-on mission to live up to the quality of Landsat 7 to date—that is, provide sunlit, well-calibrated, 30-meter-resolution data in the seasonal coverage of the global land mass. He noted how Landsat was currently considered a moderate-resolution system along the continuum from nearly global, daily coverage with coarse resolution to narrow, high-resolution imaging gathered on demand. Thus Landsat sat somewhere between the publicly funded low-resolution systems and the heavily commercial high-resolution systems. Its unique combination of resolution, global coverage, and cycle time made its continuation essential, he added. Data from this mission were destined for the imaging archives that USGS was mandated to maintain.

Dr. Irons indicated that the draft data specification was based in part on the Landsat 7 Enhanced Thermal Mapping Plus (ETM+) on-orbit performance, although NASA/USGS were also looking for an infusion of new/mature technologies to improve performance and decrease cost. Among the parameters specified in the draft document were temporal and geographic coverage (seasonal at global level, 16 days for U.S. coverage), quantity of data, acceptable cloud cover, spatial resolution for each required spectral band, inclusion of cirrus cloud band, band-to-band registration, orthorectification, and geolocation. The document did not, however, specify swath width or orbital altitude. International ground station data transmission was neither required nor precluded. Finally, a thermal band was not retained in the draft specification, although this was controversial and open to discussion.

After Dr. Irons asked participants to comment on the data specification online and in the workshop, he open the floor to discussion. When queried about the process and timeframe for input and review, he suggested that comments should be received by the end of the month (January). Although the review process had not been planned in detail, it certainly included feedback from the workshop, which would be presented to management at NASA and USGS for consideration. He said that development of the RFP was unfolding out of the context of the 1992 law advocating greater private participation in earth observation missions. If the present approach did not produce any

viable bids, USGS and NASA might revert to more traditional procurement procedures. At this point, conference participants took a short break before the panel sessions.

Science Panel

The first panel event started with introductions of the presenters to follow. Moderator Sam Goward indicated that the panelists would each address question 1 (Define the scientific mission of LDCM.) on the program agenda and any of the next three as they saw fit.

Dr. Skole. A professor at Michigan State University, Dr. David Skole began by emphasizing his interest in the first two questions (Define the scientific mission of LDCM, and describe the attributes critical for achievement of this mission) on the agenda. Calling Landsat 7 a major achievement for the science community, he described how the satellite had contributed to advances in areas that the National Research Council (NRC) had defined as grand challenges in environmental science, particularly land use. Shifts in land cover, he said, represented the other (relative to climate modification) critical element in global environmental change. He quoted a soon-to-be-released NRC report that cited Landsat's role in the quantification of large-scale land use development.

The Landsat program had also triggered the emergence of new disciplines, such as economics and demography, within the context of global imaging. New agendas were also emerging. For example, the U.S. Global Change Research Program had recently generated a 10-year plan based in part on the use of Landsat-like data for the assessment of land use and land cover change. There was a similar need for Landsat data continuity within the U.S. National Carbon Cycle Research Program. At the international level, the Kyoto protocols called for verification tools with Landsat capabilities.

Landsat data were in demand by such organizations and initiatives because of the extended analytical powers possible with their use. Researchers could move beyond simple classification to monitoring of continuous fields. Subtle changes in forest cover, for example, could now be detected. Dr. Skole displayed scenes from the Amazon basin to illustrate the level of resolution obtained from such data. He noted how Landsat images, when coregistered and validated with output from high-resolution instruments such as IKONOS, could produce outstanding results.

Dr. Skole concluded by giving an illustration of the potential of Landsat imagery for commercial development. He noted that the Massachusetts-based firm Raytheon had entered into a $1.5 billion environmental monitoring contract with the Brazilian government. By exploiting the availability of Landsat data, the company would be providing vital services to its client while creating 20,000 jobs in the United States.

Dr. Cohen. U.S. Forest Service researcher Warren Cohen spent the largest portion of his presentation on the scientific mission of the Landsat program. He noted that in his field, Landsat data were usually at the base of the analyses. The archived output from this program allowed researchers to characterize the state and dynamics of ecosystems

with respect to current or past policies and market forces. He showed slides from three studies—from the coastal areas in Oregon, the greater Yellowstone ecosystem, and the Bigfoot Project —to show how Landsat helped the Forest Service determine net primary productivity and understand natural process and landowner responses. What was important in these studies, he suggested, was the need to evaluate land use change on a regional scale. While acknowledging the complementary importance of detailed imagery at the woodlot/small-farm level, he emphasized the larger geographical scale of the policy and ecology issues. Landsat was tailored to this scale, whereas 250 IKONOS scenes would be required to equal the extent of a single Landsat scene. Doing regional analysis strictly with IKONOS type data would present a data processing nightmare given the expected diversity of viewing conditions, he said. Like previous speakers, Dr. Cohen focused on the intermediate position of the moderate-resolution Landsat, situated between the broad spatial extent and much shorter revisit time of low-resolution missions like MODIS on the one hand, and the constricted capabilities of highly focused but almost one-time approaches like IKONOS and aerial photography.

Turning briefly to the other three relevant questions on the agenda, Dr. Cohen first cited several key attributes of the current system, including radiometric and geometric qualities, temporal and spectral properties, level 1 processing, and the benefits of data sharing and low user cost. He then suggested some desired improvements in Landsat, including better temporal resolution; higher sensitivity to subtle ground features such as modest landscape degradation; routine terrain and atmospheric correction; and sharpening of spectral bands. Finally, he concluded that he had no problem with a commercial data buy as long as Landsat quality was maintained or enhanced. It would be better to build a Landsat clone and fly two at once (for greater temporal and spatial coverage) than to jeopardize current capabilities. He cautioned that increases in user costs would mean that fewer scientists would be learning about the planet at a time when more knowledge would be needed.

Dr. Bauer. The next presenter was Dr. Marvin Bauer from the University of Minnesota. He suggested that whenever synoptic imaging of moderate resolution was needed, Landsat could serve a central role. Calling the Landsat program a major technical achievement and international asset, he said that perhaps its greatest strength was the ability to detect changes in land and water resource quality over time. He illustrated this by showing several slides of changes in land use and water quality in Minnesota. The images reflected both the pace of urbanization and the level of water clarity at different points in time.

Next Dr. Bauer set forth what he saw as the most important characteristics of Landsat continuity. These included the various spectral bands, radiometric calibration, spatial characteristics, temporal resolution, and archival resources. Landsat's synoptic coverage was almost unique within current technology, he continued. The system's mix of capabilities lent itself to opportunities for synergism with other systems. Looking to the follow-on mission, he suggested that continuity did not mean maintenance of the status quo. He recommended taking advantage of new technologies to improve current capabilities. Finally, he expressed a desire for the Landsat data to remain affordable.

The current pricing structure had been a real boon to those in the greater research community.

Dr. Norman. A researcher from the University of Wisconsin, Dr. John Norman began by expressing emphasizing the importance of looking toward the future, which meant moving beyond the traditional scientific focus on classification to the monitoring and understanding of surface processes. For Dr. Norman, retention of at least one thermal band within LDCM was an essential part of this enlarged challenge to researchers. Because the draft data specification did not call for inclusion of this band, he argued strongly for reconsideration of the issue. The thermal band, he maintained, was vital to monitoring of impervious surfaces and other features of urban areas. Robust techniques were now available to exploit the potential of thermal data. He mentioned the polygon method, as well as a synergistic model combining input from GOES, MODIS, AVHRR, and Landsat. A collage of images was shown to illustrate the concept.

Dr. Goward. A scientist at the University of Maryland, Dr. Goward immediately homed in on the unique capabilities of Landsat for truly global monitoring of land dynamics at a scale in which both natural and human disturbances could be recorded. Referring to an image of the national capital area, he noted how its was only when spatial resolution approached the 30-meter level of Landsat did the road networks, buildings, and other human artifacts become discernible. Such depictions were particularly significant because they revealed how human activity now accounted for the largest form of land use modification around the world. Because such change was so varied, it would be impossible to characterize it all without the type of observatory that Landsat provided. As such, the Landsat mission was fundamental to the development of earth systems science.

Looking ahead, Dr. Goward suggested that one previous limitation—the processing of global, multitemporal volumes of enormous scale—was no longer an issue. Now a relatively modest investment in a "pile of PCs" could reduce data processing time to a matter of hours.

What Dr. Goward saw as the larger challenge was the extent to which Landsat continuity would be driven by science and data access. He referred to the commercial period of Landsat operation, which he said set earth science back 15 years. Many researchers in less affluent countries were not always able to share in the data trove during this time, and as a result the very foundation of global knowledge exchange and development was undermined. It was critical, he suggested, for the LDCM to continue the more recent policy of open data sharing. Beyond this, it was important to recall that the original impetus for earth observation was advancement of the science. The issue of rational costing raised questions about the future of this science. Thus, the cost of global, seasonal coverage as represented by 40,000 Landsat scenes—whether $160 million in the commercial era or $20 million today—was prohibitive for many users and would remain so even if drastically reduced. The real question was whether cost restrictions would give way to a recognition that Landsat should continue as an end-to-end science mission.

Dr. Justice. The next speaker was Dr. Chris Justice from the University of Virginia. Beginning with the question of scientific mission (question 1), he viewed Landsat as a critical observational tool for understanding global change, especially for land use and land cover. This observatory drove development of a global database, analysis of seasonal processes, and operation and validation of land use and hydrologic models. He described how the mission was also key to the continuation of various initiatives, including the U.S. Global Change Research Program and the carbon cycles studies under way.

Turning to the second question (critical attributes), Dr. Justice listed several program features critical to mission success, including the need for systematic science quality data, calibration and stability, radiometric performance, geolocation, an operational data quality system, and science review panels and workshops. He also cited the benefits of continuing a global acquisition strategy, maintaining adequate data availability, and sharing data to promote broad scientific collaboration.

When looking at possible system improvements (question 3), Dr. Justice suggested distinguishing between the essential and the desirable. His chief priority for system upgrade was enhancement of the signal-to noise ratio. He also mentioned how scene cost reduction to $50 could have a major impact on research project budgets.

Dr. Justice addressed the fourth question (How might a commercial data buy address and satisfy a science mission?)by saying that he was skeptical that a commercial data buy could satisfy the needs of the science community. He thought that is was critical to maintain the affordable data access of the current Landsat operation. Dr. Justice also suggested, however, that commercial partnerships could be highly desirable and held much promise, particularly in the case of value-added resellers. He concluded by reaffirming the vital role of Landsat-generated science on the national and international levels.

Science Panel Discussion. During the brief question-and-answer period that followed, Dr. Goward addressed a query about the process of prioritizing requirements for a data specification. He suggested that Landsat-7 provided the baseline, although he also noted that this mission was using 1970s technology. It was also important to consider what could be reasonably achieved with current technology. The data specification requirements should be derived from the overriding science goals, he continued. For example, if global change detection was a major goal, then project decision-makers could look for the best technical specifications to achieve this capability.

A concern emerged about the lack of emphasis on maintaining the WRS-2 scene reference scheme. In the study of change detection, this scheme was seen as vital to the control of key acquisition variables, such as sun angle and atmosphere. By not requiring WRS-2, a follow-on mission could jeopardize the usefulness of the data for change analysis. Dr. Cohen agreed 100 percent.

A question arose about the openness of the science community to a reduction in image size, given no change in pixels per image. Dr. Skole responded by suggesting that a 180- to 200-km swath width was needed for large-area assessments. This type of coverage made Landsat quite useful for parameter retrieval and detection of landscape characteristics. IKONOS, on the other hand, excelled at resolution of objects and features. Together, they were strongly complementary; neither could replace the other. Dr. Goward also responded by citing two factors relevant to image size: atmospheric variability and solar zenith angle. The first could be adjusted for, but the second created inescapable incompatibilities. Images taken at different times gave different views of the same landscape. If image size could be reduced while maintaining the solar zenith angle characteristics of the Landsat observatory, then something of merit might have been achieved.

Another questioner asked about the process for arriving at consensus about a sensor—for example, a thermal band. Dr. Justice replied that deliberations should start by defining the science requirements and engaging in dialog within this context. Dr. Norman suggested that the data were what moved the new science. The science community needed to ferret out and bring together information from many different sources to make the right decision.

At this point, the workshop recessed for lunch.

Data Providers Panel

Introductory Remarks. The afternoon session began with several announcements, including a reminder that the draft data specification was already on the Web and that many of the day's presentations would also be posted there. Mr. Byrnes then indicated that Dr. Jay Perlman would replace Dr. Leo Andreoli as moderator of the Data Providers Panel. Next, Dr. Perlman reviewed agenda questions 5-8 (Which specs are cost drivers/which do you support the most/least? What requirements preclude commercial viability? How can the Landsat Program evolve into a more fully commercial enterprise? What are the considerations regarding the inclusion of the international cooperator network in LDCM?) and provided a brief backdrop to the discussion to follow. He noted how the high cost of data during the commercial period of Landsat 4 and Landsat 5 failed to create robust participation in the program. In contrast, Landsat 7 had scaled user cost to the expense of meeting user requests—i.e., at a small fraction of the previous cost. A key challenge to LDCM, he said, was to explore ways that commercial involvement could recoup the multimillion-dollar capitalization of a Landsat observatory. It would also be necessary to consider the potential for reducing the cost to produce data and for increasing the value of the data gathered.

Dr. Faintich. After self-introductions of the panelists, Dr. Marshall Faintich of Orbimage began by noting the pivotal cost factors that determined commercial interest in a satellite venture—i.e., the cost to design and build a system, to operate it, and to rectify data. He then laid out several options for government-commercial partnerships, including a postlaunch government purchase agreement, a prelaunch data buy, and

Government-funded construction and launch. Attention was given to the experience of his own firm within this context. He noted how commercial sensors placed aboard Government satellites could perform functions different from those of the main mission by providing a smaller image size, higher resolution, or another pointing capability.

Turning to data rights, Dr. Faintich explained why he thought commercial products from a mission often needed to be segregated within the total mission output. His company did not have objections to NASA's sharing of satellite data with other researchers for purely scientific and educational purposes. Sharing commercially developed and enhanced products with those in competition with the contractor, however, undercut the incentive for private participation. He also did not want the Government itself to compete with its business partners. He concluded by mentioning how Federal agencies could become anchor tenants within a public-private partnership.

Mr. Kerridge. The next presenter was Mr. Jeff Kerridge from EarthWatch. To place LDCM within the context of the larger remote sensing field, Mr. Kerridge showed a slide of a Landsat 7 mosaic covering the U.S. land mass. The price for this entire image composite was a reasonable $100,000, or less than a penny per square kilometer. To buy 1-meter orthorectified data for this same area would cost $200 million--$20 to $30 per square kilometer. He gave examples of the factors driving instrumentation costs. Whether it was possible to lower the system acquisition budget was not clear to him. As for increasing the cost of data, he thought that there would be an outcry from the user community. The expectation was for data expense to go down, not up. Mr. Kerridge bypassed the question about the options for Landsat program evolution by posing his own query: Should Landsat be commercialized? He agreed with previous assessments that the program was not commercially viable in its present form.

Mr. Colabatistto. Representing SPOT, Mr. Colabatistto concentrated on the viability issue raised in the agenda questions. For businesses, it was axiomatic to control costs, develop products attractive to the market, and produce revenues that exceeded costs. In emerging markets, however, risk also became a pivotal issue. For example, he noted that firms competed not only for business but also for capital. Investors with venture capital were quite sensitive to risk, as well as to projected market return and associated cost. When the Government joined in a private partnership and, for instance, carried out or insured a launch, the attractiveness of the mission to industry was significantly increased. He cited the worldwide experience of Spot as a testimony to the productiveness of such partnerships. In these arrangements, it was important for the public partner to bear any costs associated with its unique requirements.

With the new Congress and Administration, there were great opportunities to capitalize on the accomplishments of the Landsat program, Mr. Colabatistto suggested. He mentioned opportunities for lowering program costs in the future. One option was to reduce requirements for onboard data processing, a powerful cost driver. In the case of SPOT, it made sense to reduce the number of data sets provided by the satellite and to acquire the increasingly demanded panchromatic data from commercial sources.

Mr. Colabatistto outlined a number of roles that the Federal agencies could play in satellite imaging. The Government could be a simple system developer, or it could serve as system operator and license rights out to bidders (as with SPOT). Also, agencies could become anchor clients, which were very important in high-risk ventures. In these and other roles, he cautioned, the Government needed to monitor its own ability to bias the commercial markets. Finally, Federal agencies could evaluate their roles as stakeholders in the long-term business cycle of partners, who may experience conditions quite different 5 to 7 years out from those evident at the beginning.

Mr. Leonard. Starting with some background on his company, Resource 21, Mr. Vic Leonard described the firm's involvement in a Russian agricultural project over the last dozen years. Resource 21 was one among many corporate and Government partners, including NASA , that employed hundreds of scientists, engineers, and others in this effort. The outcome was a system specification for an agricultural production program. This research relied upon input from various Landsat spectral bands.

Turning to the agenda questions, Mr. Leonard mentioned that his company liked to listen to its customers about what they required in terms of spectral bands and other technical specifications. He suggested that it was important to balance customer needs with shareholder interests. In the purchasing practice area, he would like to see long-term service contracts and investor comfort. He also underscored the importance of appropriate data pricing policies and the role of the international ground stations.

Mr. Doyle. The next panelist to speak, Mr. Fred Doyle of Space Imaging, agreed with previous presenters about the value of the Landsat data. The critical issue was: At what cost? He argued that commercial viability required all costs—reproduction, operational, product—to be recovered. Some examples of failure to recoup investments were given. Commercial interest depended in part on the willingness of Government to be an anchor tenant or supplier of investment infrastructure.

Shifting to the agenda questions posed to the panel, Mr. Doyle first listed specification requirements that might drive up project costs. These included the bands indicated (especially the thermal band), resolution, and scene size. As for contributing factors to successful commercialization, he cited pricing, which needed to reflect system cost. One alternative to simple system continuation would be to place the anticipated Landsat funding into the hands of users through grants and other types of programs, and to buy the desired information at the true market price. Another option would be deregulation, but only in a context in which firms were not bound by market ceilings. Finally, for question 8 (regarding the inclusion of the international cooperator network in LDCM), he agreed that there was commercial potential in the international Landsat ground station network. His concern here was the role of the Government, especially any strings that might be attached.

He concluded by saying that the migration of Landsat into another phase depended upon how much the Government would buy and at what price. He was interested in knowing

about any guaranteed data purchase. The public commitment to maintaining an image archive could influence commercial participation in a partnership.

Dr. Perlman. The panel presentations came to a close with a few observations by Dr. Perlman. The first raised a fundamental question about the appropriateness of a service pricing analogy for Landsat: What if the Interstate Highway System had been developed as a toll road network? The second comment underscored the deeper significance of earth science technology with respect to long-term survival of the human species. Another comment focused on the need to explore ways to reduce costs through the efficiencies of mass production and larger scales. Dr. Perlman also suggested that the Government needed to understand what the debt and equity requirements of the marketplace really were. Finally, he asked what was meant by the term "commercial."

Data Providers Panel Discussion. Mr. Francis Thompson of Aerojet offered several comments after the panel discussion. He noted that there were several successful models that should be considered within the context of LDCM, including GPS (the Global Positioning System) and AMSU (the Advanced Microwave Sounding Unit flown on weather satellites) which provided real-time data on the Web. Also, he said that a data buy, viewed over the life cycle of a project, was actually more expensive than an outright purchase because in the former, the corporate partner had to bear significant risk. If a data buy were sufficient to cover costs and Aerojet agreed to the purchase, the company would not also press to retain data rights. He wondered whether the companies represented on the panel wanted something more than cost recovery out of a contract. Dr. Faintich observed that if the Government expected a company to recoup some of its own costs out of the data, then the Government should not compete or give data away.

A number of questions revolved around the demand or lack thereof for 30-meter data. One questioner wondered whether anything had really changed in the market to make this type of data more salable. The panel consensus was no: Firms were not going to invest in producing more of these data. For this reason, the European Space Agency model was not applicable. SPOT did not seem like an attractive model to the panel either, because of industry resistance to Government competition in high-resolution imaging. Dr. Faintich suggested that because Landsat and the high-resolution satellites were complementary, Landsat actually served as a plus for his company's work. He and Mr. Doyle agreed that high-resolution instruments would never replace the 30-meter tool. Toward the end of this discussion, Dr. Goward expressed his sense that the panel was sending a mixed message—i.e., that Landsat type data were important and irreplaceable on the one hand, but not commercially viable on the other. There was also some discussion about the viability of resolutions located between the 30-meter level and those resolutions under 5 meters. Mr. Leonard suggested that a market existed for 10-meter data. It was not clear exactly where the cutoff resolution point was for commercially attractive data sets.

Data Users Panel 1

Dr. Janetos. After preliminary remarks by Mr. Byrnes, panel moderator Tony Janetos of the World Resources Institute offered a series of observations about the Landsat program. He said that increasing evidence was showing how valuable the seasonal, global data derived from the satellite had become. For the first time in a decade, it was possible for users to query the system for any point on the globe, thereby fulfilling one of the main promises of this mission. Dr. Janetos also referred to the enormous user empowerment resulting from the relaxation of restrictions on data copying and redistribution. Even with this progress and the decline in scene prices, however, $400 to $600 unit costs were still prohibitive for many small, nongovernmental organizations (NGOs).

Despite these barriers, he predicted that within the coming decade, regional and world-scale analyses of seasonal information would become the norm for governments, NGOs, and corporations concerned about their natural resource holdings. He mentioned the Millennium Ecosystem Assessment, which had already raised $15 million, as an example of the type of enterprise that could tap the potential of Landsat's capabilities. One of the reasons that more organizations could take advantage of this resource was that computing costs had declined dramatically. In the future, labor costs would become the larger issue.

Turning to the LDCM outlook, Dr. Janetos maintained that the Government had a responsibility to ensure maintenance of the public good through programs such as Landsat. Of course, data cost remained the greatest challenge. Although the present system was expensive, it worked. He concluded by suggesting that NASA and the USGS adopt a metric that would seek to preserve the program elements that worked and to fix the problematic ones.

Dr. Echavarria. Representing the Bureau of Oceans, International, Environmental, and Scientific Affairs within the U.S. State Department, Dr. Fernando Echavarria used his presentation to demonstrate the various ways that his agency was a stakeholder and data user with respect to the Landsat program. These roles grew out of the department's increased commitment to foster scientific knowledge and capabilities inhouse, as well as to harness recent advances in geospatial and information technology. Dr. Echavarria cited a long list of activities that reflected this growing interest, including speeches by Department executives and internally sponsored workshops on remote sensing. Partners included the National Research Board (Space Studies Board), American Institute of Aeronautics and Astronomics, and the National Oceanographic and Atmospheric Administration. The driving force behind these efforts was to use science to advance the U.S. diplomatic agenda, including sustainable development in all regions of the world.

Another factor contributing to the ascendancy of earth systems science within the State department was the proliferation of treaties, bilateral agreements, and memoranda of understanding—which had almost tripled since the 1992 Earth Summit in Brazil. Dr. Echavarria mentioned a number of discussions and agreements that the United States had been party to, including the U.S. Framework Convention on Climate Change. Land use and cover, particularly forest cover, were of special concern.

Dr. Echavarria concluded by expressing the department's desire to receive scientific input from agencies such as NASA and the USGS. Although his agency's resources in this area were limited, there were still many activities of national and international environmental import emanating from there.

Dr. Beck. Representing OHIOVIEW, Dr. Richard Beck traced the development of his consortium of satellite data users. He noted the origins of his organization in 1996, when there was a lack of timely access to remote-sensing data for education and research. Since that time, there had been an explosion of data use in Ohio, with activity up by a factor of 10 and, perhaps within another year or so, by a factor of 100. The consortium had grown beyond a nine-university pilot program into a broad-based network also encompassing libraries and governments in 19 States served by the core group and 14 commercial partners (data providers, value-added resellers, and research laboratories). The project created laboratory and classroom materials and provided university students and researchers access to satellite data for their work. More information on the organization was available on the Web at http://gateway2earth.org.

Landsat 7 imagery served as the foundation for the OHIOVIEW project, Dr. Beck reported. The consortium purchased approximately $130,000 worth of Landsat data annually, with the costs shared among members. Once students were exposed to the possibilities of working with these data, they developed interest in higher resolution images as well, such as those from IKONOS.

Dr. Beck made a number of recommendations to the Government about continuing and upgrading the Landsat system. There should be a series of 30-meter, full-spectrum sensors with 10-meter sharpening available to researchers, he suggested. He also proposed that NASA and USGS expand the range of resolutions available through the program, including sub-5-meter-resolution data. Inclusion of an infrared band would likewise be useful. Data could be placed in the public domain after several years of commercial exploitation. What was needed overall, he argued, was access to affordable, hassle-free, entry level satellite data.

From the commercial sector, Dr. Beck called for funding to help create an annual national and global Landsat mosaic. With respect to product pricing, he asked for generous allowances to be made for educational and governmental researchers, who he said posed no competition to the aerospace industry. On the other hand, he recognized the need for the commercial sector to make a return on its investment. He likewise acknowledged that the professional future of his students depended on a healthy commercial climate. What he was seeking, he concluded, was a balance between private economic return and the greater public interest.

Dr. Gabrynowicz. Professor Joanne Gabrynowicz of the University of North Dakota provided a legal overview of the issues at stake in the LDCM. She began with the 1992 Land Remote Sensing Policy Act, which set forth goals promoting national security and commercial interests, less expensive operations, and responsiveness to data users. The

legislation expressed a preference for a private system if it could be funded and managed by industry while achieving statutory goals.

The 1998 Commercial Space Act amended the 1992 law. The new legislation encouraged the use of commercial providers to the extent possible, allowed for airborne sensing systems, and treated data as a commercial item under general Air Force procurement policies. Cost-plus contracts were precluded under this act. The right of a contractor to restrict data use was linked to the presumption that the item in question was developed exclusively at the contractor's expense.

New NOAA regulations were also relevant, continued Dr. Gabrynowicz. Under these, data ownership was defined according to the level of resources disclosed to have been funded by the Government. Data from projects paid for entirely by taxpayers had to be made available on a nondiscriminatory basis. The output from exclusively privately funded missions could be distributed under reasonable commercial terms. In cases of partial Government funding, data access would be determined case by case. Dr. Gabrynowicz read various definitions of key terms in the NOAA regulations, including references to "commercial," "commercial purchase," "commercial use of Federal assets," and "privatization."

The various laws and regulations on the books had produced some discrepancies and ambiguities. In 1992, the minimum user base was all users without preference; the 1998 act, however, defined these as NASA and other Federal agencies, at their discretion. The statutory picture was also clouded by inclusion of airborne sensing in the 1998 legislation, which raised another set of legislative and regulatory issues involving the Federal Aviation Administration. There was at least one legal challenge to suggest that in ambiguous circumstance, the courts might look to the 1992 legislation for specific guidance on a number of issues. Dr. Gabrynowicz suggested several questions that could resolve uncertainties and disputes involving legal requirements: Who would be paying for what? Who would manage—civil servants or private employees? What would be managed, day-to-day operations, Government or private equipment, etc.? Who would ultimately be liable? Finally, who would actually have authority over data services, distribution, and acquisition?

Dr. Doorn. The last presenter from the first Data Users Panel was Dr. Brad Doorn from the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture (USDA). Declaring that Landsat was a system that worked, Dr. Doorn identified some of the program's other heavy users within USDA, including the Forest Service; Foreign Service Agency; National Agricultural Statistics Service; Cooperative Research and Education Service; Animal, Plant, and Plant Health Inspection Service; and Rural Management Agency. The Landsat data contributed significantly to the data stream that drove assessment and forecasting across this wide spectrum of agricultural agencies.

Since the price of Landsat scenes dropped to $500 for the USDA, FAS has purchased between 2,000 and 3,000 annually. The agency uses these data to pursue its overall mission to produce the most accurate assessment of global crop production, which served

as a baseline to other data brokers. Although satellite imagery was just a piece of the larger constellation of data sources, sometimes it represented the only way to obtain valuable information.

The contract for image acquisition was recently up for review. Because of the way the Landsat system was set up, it was possible to let out a contract to the lowest bidder (via a Request for Quotation, RFQ) rather than proceed with a request for proposal (RFP), which was a more difficult route.
Perhaps foremost among Dr. Doorn's concerns was the need for increased temporal resolution. With cloud cover degrading a significant percentage of images, it was easy to miss an entire growing season. In addition, one acquisition per season just did not provide adequate content for analysis. He showed an example of winter wheat in Eastern Europe. Only because FAS was able to compare images taken 16 days apart was it able to assess the robustness of the crop. When Landsat's temporal resolution did not allow for adequate resampling, FAS was forced to resort to a shotgun approach to obtain the appropriate agricultural data. Also, when food aid decisions were at stake, access to current data was critical. He suggested that after 12 days, depreciation of imagery was drastic. Although archived data would continue to play a significant role, it was highly desirable to have an operational system that allowed easy, timely analysis and comparison with other types of data, as from IKONOS

Dr. Doorn also emphasized the important of global coverage. The status of the Chinese corn crop could be as important to corn farmers in this country as the status of the American crop. Landsat plays an important role in this macroscopic context.

Data Users Panel 1 Discussion. Dr. Gabrynowicz led off the discussion session by commenting on agenda question 12 (requesting input on any desirable legislative changes). She suggested that a shift was not needed at the legislative level, but rather within the problem-solving approach. Her key concern was to distinguish between different kinds of data sets. Certain data were of great value to the public and scientific community, whereas others had major commercial appeal. She thought that it was important to acknowledge that a distinguished panel had just gone on record confirming the overall industry response to the LDCM Request For Information—namely, that there was no commercial interest in Landsat. Another participant observed, however, that the panel had not found Landsat to be valueless; rather, panel members had simply agreed that the system was not a profitable option for them.

Dr. Justice commented that his overall sense of the day's sentiments was to keep Landsat as it was. Dr. Doorn agreed, adding that this conclusion needed to be formalized among the various Federal agencies using Landsat data. Dr. Justice asked whether there was an appropriate forum for these agencies to voice their requests. Mr. Byrnes replied that for some time USGS had hosted the Landsat Civil Agency Requirements Working Group, which served this very purpose. Dr. Echavarria expressed his strong desire to see the State Department participate in such agency dialog. Landsat, he continued, was a tremendous foreign policy asset worthy of preservation.

Dr. Goward initiated an extended discussion about the merits of a commercial data buy. Dr. Janetos stated his perception that the Landsat system, while enormously valuable to the science and environmental communities and somewhat valuable to certain companies, could not depend upon industry to raise the capital required for building and operating a follow-on mission. Only a partly commercial, mixed model seemed likely to succeed. Dr. Gabrynowicz asked whether a data buy might generate data only of interest to NASA. There was also potential for the data requirements of a purchase to fall into the mire of acquisition regulations, policing, and verification. Dr. Doorn expressed similar reservations based, in part, on USDA's experience with a commercialized data acquisition process. If a data buy were to lead to higher image costs at his agency, there would be budgetary and administrative pressure for forecasting to become more accurate without better data input. What was needed was an ongoing system that provided the information required, not one that required sealed bid contracts every 5 years. Dr. Gabrynowicz pointed out that not all data buys were the same, considering that some data sets were extremely perishable; generalizations should thus be made cautiously. Dr. Faintich reminded participants that when a mission was fully funded by a commercial firm, the data sold to NASA could be kept proprietary indefinitely, even if Web site postings suggested otherwise.

Dr. Janetos praised the quality and data availability associated with Landsat 7, but he also recalled how the international ground stations had almost been left out of key decision-making within the system. These stations did, fortunately, sign agreements with the USGS that recognize the U.S. Government's ownership of the data, according to Mr. Byrnes.

One of the last ideas to surface was the suggestion for agencies and other scientific data users to develop a cooperative in which members would share risks, benefits, and costs. Mr. Byrnes noted that this concept had arisen in the past, and suggested that it merited further consideration.

Mr. Byrnes and Dr. Wende thanked participants for their attendance and contributions during the day and asked them to return Wednesday to hear from an even wider range of speakers. The meeting was recessed until 8:30 of the following morning.

Wednesday, January 10

The morning session began with another welcome from Mr. Byrnes, who further encouraged participants to comment personally or electronically about the LDCM. He singled out several individuals for contact: Dr. Jim Irons of NASA to receive input on the data specification; R.J. Thompson, Landsat 7 Program Manager, and Dr. Bruce Quirk, Chief , Satellite Systems Branch, both with the USGS EROS Data Center to receive questions and creative suggestions on public-private options for sharing LDCM equipment or services ??}}. Mr. Byrnes said that he and Dr. Wende would also be available for direct discussionsand reminded participants that the meeting was being recorded and that a summary would be posted on the Web.

Data Users Panel 2

Dr. Lillesand. After introducing panel members and recounting his involvement in the field, University of Wisconsin researcher Tom Lillesand said that he would be using three examples from his home base to illustrate the multiplier effect of Landsat . The first was the WISCLAND Partner Project, which encompassed a number of agencies committed to producing a State-wide land cover map at 30-meter resolution. The elaborate classification process used in this effort wound up costing $110,000 per scene. Now there was legislation requiring every municipality in Wisconsin to approve a land use plan by 2010 or lose the authority to enforce subdivision regulations and other development controls.

The second example cited was a project to monitor lake water quality and its relationship to the greater landscape and human activity. The initiative recruited over 600 volunteers to carry out ground observations at the same sites and times as those sampled by Landsat overpasses. Monitoring the dynamic nature of lake water quality was constrained, however, by the insufficient temporal resolution of Landsat imaging. The project was saved by the use of daily, 250-meter-resolution data from MODIS, whose overall performance in this particular application equaled or exceeded Landsat's.

Dr. Lillesand's final example was an initiative to design a weigh-in-motion station for trucks regulated by the State's Department of Transportation. Project planners began with ETM+ data to obtain an overall understanding of the site. These data allowed for a review of potential alignments, incompatible land uses on nearby sites, distances to overpasses, and soil overlays. Analysis proceeded to higher resolution imaging and the commercial development of an onground, fully digital documentation system to produce siting options for the facility.

Dr. Lillesand emphasized that ETM+ is the gateway to a much larger realm of satellite imaging and commercial opportunity. He also stressed that Landsat had far more than commercial value. It was an indispensable public good and vital capital investment in the Nation's infrastructure. In light of this, he summed his own testimony before policymakers some18 years ago: Don't raise the cost of Landsat data.

Ms. Santoro. The next speaker was Ms. Mary Pat Santoro from the Topographic Engineering Center within the U.S. Army Corps of Engineers. She suggested that her comments, although based on Army practices and preferences, applied to all the armed services. Remote sensing, she said, was important to the military for a variety of national security and humanitarian purposes. Landsat was central to this mission because the system provided seasonal, global monitoring capabilities and thereby addressed the Department of Defense's ongoing interest in change detection. Another advantage of Landsat was the relaxation of restrictions on data distribution. This meant that the military could offer relevant satellite imagery to coalition partners, as well as to State and local governments seeking disaster relief.

Cost was another significant factor in Landsat data utilization by the military. Imagery at higher resolutions was often less accessible, more expensive, and complicated by licensing agreements. The Army did use these other sources but was constrained by budgetary requirements.

Ms. Santoro described a number of civilian arenas open to remote sensing in which her agency took an active interest. These included engineering, water resource monitoring, drug law enforcement, lines of communication, and damage assessment.

Overall, the military needed all levels of image resolution to fulfill its mission. Landsat in particular had been a huge asset for the Army in locations of interest throughout the world, she concluded. Continuation of the system was needed.

Mr. Wells. Representing the Texas Natural Resources Information Center, Mr. Gordon Wells began by describing the various types of remote sensing imagery gathered and analyzed by his agency. It was customary in Texas, he said, to place the different data sets obtained into a common reference framework. All the high-resolution imagery used by his office overlaid the Landsat data set. In the last few years, interest in remote sensing data had grown beyond the usual resource conservation and development groups and had begun to attract the attention of individual ranchers and farmers. With the purchase of inexpensive software, they could use this information to manage their resources. Mr. Wells noted that all the data compiled by his agency were in the public domain and that the only charge to users was for reproduction. A forthcoming project would expand data dissemination further through purchase of a 10-meter-resolution data set from SPOT for the entire State. These images would be made available to all State agencies, Federal cooperators, regional and local governments, and schools and colleges, and would be viewable on the Web at full resolution. After a negotiated period of time, the data would go into the public domain.

Mr. Wells next described in some detail a number of instances in which Landsat data contributed to emergency management. He showed slides of the types of imagery used for assessment of hurricane damage and search-and-rescue requirements, before-and-after drought conditions, and wildfire control. Included among these were three-dimensional projections developed from satellite data to prepare and protect work crews. (Also

depicted were other scenes with perspectives derived from LIDAR digital elevation models.) He talked about the value of assembling pre-event Landsat imagery to help evaluate a crisis.

The final part of Mr. Well's presentation focused on various ways to support the LDCM. He recommended that the Landsat system be melded into the National Spatial Data Infrastructure Framework. Another suggestion was to provide near-real-time data through university laboratories and Internet-2. He said that the LDCM would also benefit from a strong focus on national science and technology education. It would likewise be helpful to focus on the operational importance of Landsat data, not only within State agencies, but in the community as well. He concluded by urging Landsat supporters to externalize system demand to a broader constituency, down to key local power brokers and decision-makers.

Dr. Williamson. The last panelist from this group to present was Dr. Ray Williamson from George Washington University. His remarks, he said, would reflect not only his work on the national policy side of the issues, but also his more recent experience as a data user. Overall, he perceived a growing need for various types of activities associated with geographic information systems (GIS), including mapping, planning, disaster response, environmental monitoring, intelligence, science, and education. Remote sensing data were just one piece of this larger context, although they were becoming a more influential component of it.

Several factors were contributing to this burgeoning network of geospatial data users, data providers, and value-added firms. One was the heightened level of global transparency, which allowed imaging of previously restricted or inaccessible sites. As a result, high-resolution data from these new areas of interest were prompting users to seek out related, moderate-resolution imagery. Other reasons for the increasing visibility of GIS and remote sensing included the enhanced ability to examine time series and monitor processes on a large scale. Laws and policies, too, had fostered Government and commercial initiatives in the GIS arena, while the global media had tracked the movement with interest.

The proliferation of remote sensing systems at the global level suggested a need for a formal international framework. Dr. Williamson laid out several advantages to the United States to support a formal international consortium for managing projects like the LDCM. These benefits would include a lower U.S. Government capital investment, promotion of earth observation data use within the international community, incentives for value-added firms, greater system robustness (i.e., smaller risk from single-satellite failure), better data exchange, and perhaps enhanced international ground station participation. Possible barriers to formal collaboration included the heritage of national security issues, dependence on partner funding and political institutions, current absence of a consortium mechanism, potential competition with private enterprise, and proliferation of national systems. Overall, however, Dr. Williamson suggested that missions such as the LDCM should not be considered strictly a U.S. problem to solve, as

the challenge transcended national boundaries. An international effort, he said, promised a more robust, reliable system for obtaining and processing geospatial data.

Data Users Panel 2 Discussion. Dr. Faintich began the discussion by commenting on the difficulty of establishing a partnership involving not only the U.S. Government and industry, but global partners as well; the complex international law and agreements entailed could make such a union unworkable.

Dr. Faintich also asked Mr. Wells about the market for Landsat products among individual ranchers and farmers. Mr. Wells responded that he had not meant to suggest that this group was buying significant amounts of Landsat material; they were more interested in data with other specifications. Even so, they were beginning to become familiar with the availability of Landsat imagery.

Several comments addressed an issue raised in the previous day's discussion of interagency contexts for discussing the Landsat requirements. Was such a forum functioning within the ranks of DOD? Mr. Byrnes indicated that he knew of one possible candidate for this role—the National Imagery and Mapping Agency's (NIMA's). Commercial Imagery Program's quarterly forum Mr. Murray Felsher confirmed the existence of this forum and invited anyone who was interested in attending the next unclassified meeting (February 6) to speak with him.

The discussion shifted back to the international consortium option. Dr. Gabrynowicz suggested that there were many models that could be explored for such a global body and that the Landsat program already encompassed a multinational membership. She suggested that the barriers to the consortium were more political than legal.

Dr. Williamson agreed, saying that some of the international legal complications mentioned earlier could be circumvented by careful structuring of a single entity within countries that would contract directly with all commercial participants.

The conversation turned to politics when Dr. Wende suggested that the concept of "public good," no matter how worthy, could not be sold to Capitol Hill. Dr. Beck, however, argued that the incoming Administration, as well as members of Congress, was open to many of the themes inherent in the LDCM—education, technology, commerce, science, and the Internet. He pointed out that his consortium was already planning to spend more on commercial data sources than on Landsat imagery, which was just the entry point into the field.

Mr. Francis Thompson of Aerojet asked Dr. Wells whether the growing stream of anticipated international satellites posed any real competition to Landsat. Dr. Wells said that as far as his agency was concerned, he would consider any option, national or international, that would provide the type of data required to meet a critical need.

The panel discussion concluded with further discussion of the international consortium concept. Mr. R.J. Thompson expressed his appreciation for all the support shown for

this model, but cautioned that it did not really constitute a viable option for the present because of the timeframe established for a follow-on mission. Action needed to be taken imminently. If interested parties wanted to pursue an international strategy in the longer term, they should immediately start to establish a working group to construct partnerships and the requisite agreements. Dr. Justice responded by suggesting that were already entities observing global and terrestrial changes and that these structures represented a start toward greater global collaboration.

Data Distributor/Value Added Reseller Panel

Mr. Hall. After a break and additional announcements from Mr. Byrnes, Mr. Doug Hall of Earthsat began his presentation with an overview of his company's 30-year history in remote sensing. The list of corporate activities covered more than a dozen scientific, humanitarian, military, and foreign policy fields. All together, Earthsat had processed almost 50,000 Landsat images.

Mr. Hall recalled how the perspective of his firm had changed over the decades, from the early surge of company sales in the 1970s, through their virtual collapse into the 1980s and early 1990s, to the restoration of a viable Landsat system with the 1992 policy act. What had become apparent from these upheavals was that the promise of commercialization had been oversold. In hindsight, a number of lessons had been learned. One was that end users for his company's fraction of the market were almost always - over 90 percent of the time - in the public sector (i.e., federal, state, and local governments), with oil and gas companies representing a modest exception.

Another insight was that the potential for continuous global monitoring had not been realized until data costs had dropped sharply down to current Landsat levels. The market remained so price sensitive that if costs for Landsat imagery rose in the future, this enormous asset might not be meaningfully utilized. Current user access was a real plus, although questions about post-acquisition data distribution still posed a critical issue for conservation groups and others.

Mr. Hall made several observations relevant to the LDCM. One was the need for maintenance of the Worldwide Reference System (WRS-2) image collection grid. Another comment recognized that there was an appropriate private-sector role in the future but that the role was not always easy to define. Even with its long corporate history, Earthsat had not been able to standardize its imaging process because each order had to be customized.

Overall, Mr. Hall maintained that there was no substitute for the Landsat data set in change monitoring. As perhaps the most important data resource of all, Landsat was a public necessity. Referring to Dr. Wende's skepticism about selling "public good" to Congress, Mr. Hall pointed to overseas corporate ventures exploiting Landsat data and deriving significant economic benefits from them. Despite their widespread utility, however, he felt that the full promise of global Landsat data had yet to be realized.

Mr. Fishman. Representing Metapath Software International, Mr. Jeremy Fishman introduced his company as a provider of software packages for companies designing wireless telephone networks. Metapath developed these products by using land use models to determine radio signal propagation patterns across target areas. The company also sold data sets, which in the last year had helped boost revenues by 277 percent. It operated in 650 locations worldwide.

Mr. Fishman reported that his firm currently relied almost exclusively on Landsat 7 data for a variety of reasons. The 30-meter spectral and 15-meter panchromatic resolutions were perfect for modeling street and landscape features and (with panchromatic data) for postclassification editing. Landsat 7 also delivered good global coverage, rapid data delivery (within1 week), and most importantly, low cost. The decline in data cost from Landsat 5 to Landsat 7 had transformed user demand. Mr. Fishman showed several slides of large-scale or irregularly shaped target areas that would have been prohibitively expensive under the old pricing structure. With Landsat 7, however, the minimum charge to customers generally covered the cost of needed data so that having sufficient volume ceased to be a factor.

The issue of commercializing Landsat prompted Mr. Fishman to propose that perhaps it had already happened, and in a highly favorable way. Not only had his firm profited significantly from Landsat 7, but there also appeared to be opportunities for other ventures to capitalize on this resource. He cautioned against any commercial plan for the LDCM that created a monopoly. All together, the present system seemed "perfect" for Metapath.

In response to agenda question 10 (What changes to the Landsat 7 Data Policy would stimulate your use of LDCM data or your business?), Mr. Fishman suggested development of stereo panchromatic imaging if commercial competition was not a barrier. Such a capability would have staggering implications for emergency management and commercial applications.

Question 16 (LDCM commitment to populating a data archive) elicited a definite "yes" from Mr. Fishman. He further recommended that steps be taken to ensure that the data from international ground stations went into the archive.

Mr. Leary. The next presenter, Mr. Tim Leary, began by describing the range of services offered by his company, ImageLinks, which was a spinoff of Harris Corporation. The heritage of the software used by his firm was the capacity to rapidly and accurately position images in target areas. This software was extremely versatile, allowing for a range of services and products, including band fusions, band subtractions (e.g., for change detection), nondestructive image processing, and layering and mosaics. Three-dimensional imaging was another capability offered by ImageLinks. The company had also developed a dynamic archive architecture that permitted user interaction with the software. Mr. Leary emphasized the advantage of being able to customize products that allowed the client to activate desired classification functions easily.

The Landsat 7 system had been extremely useful in the development of these highly complex, flexible products, Mr. Leary observed. He cited the benefits of low cost, rapid data turnaround, and high quality. The market for the moderate-resolution imaging of Landsat would always be there, he suggested, as a complement and entry point to higher resolution systems, such as SPOT and IKONOS.

Somewhat offsetting these Landsat benefits was the significant (although now lower) expense of large-scale data sets— well over $1 million for a global package. Perhaps, he suggested, a pricing structure for global data sets could be developed that would be different from that applicable to smaller sets.

Another qualification to his enthusiasm for the Landsat data cost was the reduced margin that his company could realize on a $600 scene relative to that for a $4,400 scene. Even so, his company had adjusted to the new market condition and continued to benefit from the overall low cost of the Landsat data.

Mr. Apponi. The final panelist to make a presentation was Mr. Giorgio Apponi of Eurimage. He provided some background information on Landsat 5 and Landsat 7 and alluded to the memorandum of understanding between USGS and the European Space Agency (ESA). Mention was made of the arrangements for cost-sharing and world-wide distribution of data.

Mr. Apponi discussed the relationship of value added companies in remote sensing to key institutions in Europe, such as the European Union, JRC, and national agricultural agencies. Eurimage already had in place a distribution network of more than 80 applications providers, linkage to ESA ground stations, and a catalog and browsing system. He said that his value added group provided a number of products and services, including raw and system-corrected data, geocoded and orthorectified products, three-dimensional output, application-oriented scene sets, and user-friendly access to data archives.

The market demand for remote sense products was increasing, and Landsat data was seen as valuable within this context, according to Mr. Apponi. At the transnational (European) level, value added companies could help develop annual agricultural statistics, land cover maps, and other information related to subsidy regulation. There were also opportunities to tie into national programs concerned with crop inventories or change detection.

Turning to cost issues, Mr. Apponi said that price per value was a key principal at Eurimage and that within this context, $600 per Landsat scene seemed reasonable. He reported that a two-tier pricing scheme—one for commercial users and another for scientific and educational users—had been set up by Eurimage in Europe. The scientific community could access and exchange data at very low prices for research and development purposes. Mr. Apponi concluded by observing that the present Landsat system could serve as a reference for future arrangements. Distribution and pricing policies should avoid competition between industry and government and take into account commercial costs and investments.

Data Distributor/Value Added Reseller Panel Discussion

The first questioner asked for the panel's reaction to the draft data specification for the spectral bands, particularly the splitting of the infrared band and deletion of the thermal band. Mr. Hall said that he did not have a problem with these changes as long as continuity provisions were made for tracking modifications over time. Mr. Fishman also replied, stating that the additional proposed bands would increase model accuracy. As such, they could be sold to customers seeking to reduce the risk of bad system design.

The panel was also was asked what, if the price per scene had to go up, would be the merit of making data available at significantly lower volume levels or leasing data for a commercially viable period. Mr. Hall replied that such changes could disturb a very sensitive market and could create barriers to use. Mr. Fishman, however, said that the lease option could be very attractive to the telecommunications industry because long-term ownership of data sets usually had little value to companies like his, which did frequent reassessments requiring new data. Leasing could also lower costs in corridor projects requiring extensive data sets. On the other hand, there was sentiment expressed that leasing, while commercially appealing, was not a practical option for a Government program trying to recoup its investment; leasing would just add another layer of monitoring.

Mr. Leary noted that his company had developed its active archive technology to get away from scene-based pricing, so as to provide clients with only what they wanted and could afford. Mr. Apponi noted that Eurimage processed scenes of varying size, including microscenes.

A question was raised about price elasticity in the marketplace. Mr. Hall observed that there were only two data points--$4,400 and $600—and it would therefore be hard to know exactly where the key price threshold would fall. He did suggest, however, that if scene costs exceeded $1,000, the market would lose interest. Mr. Leary agreed.

Panelists were asked to speculate on their industry 5 years into the future. Mr. Hall estimated that the worth of the value added market would probably be in the low hundreds of millions, with data sales accounting for only $10 million to $20 million. The principal users would be government agencies, he said. Mr. Fishman suggested that the telecommunications market, for all its current vitality, might not be as robust in a few years as this field matured and a steady state was approached.

The final question to the panel dealt with the effects of slight changes in the quality of data acquired from vendors operating in many different countries. Mr. Hall said that such variation degraded product quality because the continuity of long-term data sets was compromised. Mr. Leary saw the problem as a set of tradeoffs among traditional market variables—quality, cost, and coverage. Product variability would complicate an already challenging equation for the client. On the positive side, data from different sources would provide customers with some choices, he said.

At this point, Mr. Byrnes thanked the panelists for their contributions to the workshop and turned the program over to Dr. Vincent Salomonson from NASA.

Open Forum

As forum facilitator, Dr. Salomonson began this part of the program by expressing his appreciation for the ideas offered thus far. He spoke about the changes and progress within remote sensing and emphasized the need to use this session to chart the best course. Now was a good time, during the change in Administrations, to clarify the issues about mission continuity. Already he sensed a consensus among the different groups represented: Landsat 7 had been of great value to the scientific, data user, and value added communities, and the follow-on mission depended on at least some level of Government participation. He asked participants to use this time to continue their exchange of ideas and to present specific strategies for the LDCM. Before the forum began, however, he asked Dr. Darrel Williams from NASA to make a special presentation on the thermal band.

Dr. Williams. Because there had been concerned expressed earlier about the fate of the thermal band in the LDCM, Dr. Williams provided an overview of the issue, as well as a clarification of his own position. He recalled that after the failure of Landsat 6 in 1996, NASA felt challenged to build a follow-on mission, but one whose economy would attract broad support. In the search for savings, Dr. Williams and his colleagues evaluated the various bands used to date and found that the thermal band had been the most expensive and the least used. An ad hoc science team, moreover, concluded that two bands were needed for accurate measurements and that sensing at certain times posed technical problems. For these reasons, Dr. Williamson recommended deletion of this band. Since that time, a well-calibrated, 60-meter thermal band on Landsat 7 had performed well. It now appeared that only one band was needed after all, and that time of day was not a problem for sensing. In addition, the critical importance of the thermal band to driving the global data acquisition process had become apparent. Thus, Dr. Williams wanted to go on record in support of retaining a thermal band if it could be done at a reasonable cost.

Group Discussion. The open forum began with a question about the market for hyperspectral data. Mr. Leary confirmed that there was a market but that it was finite. He was not certain of its full extent.

The discussion turned to the international repercussions of the LDCM. Dr. Echavarria expressed concerned about the small representation of the global community in the room. He emphasized that people all over the world, including the Chinese, Brazilians, Japanese, and South Africans, were anxiously awaiting a clarification of the follow-on mission. Dr. R.J. Thompson agreed that the level of international interest in LDCM had escalated because many countries like South Africa had invested significant amounts of money in ground station upgrades. They deserved to receive a clear indication of the U.S. Government's intentions with this program. It was also observed that the history of

Landsat was marked by changes in parameters like band width. More continuity was needed to ensure that international partners could have a firm sense of the reception capabilities required for international participation.

Dr. Goward commented on the tendency for the science and business communities to view one another as adversaries. He maintained that the resolution of the LDCM required all parties to overcome their partisan interests and to pursue an overall outcome benefiting both constituencies.

Dr. Brecher reported that many local governments were unable to afford the extensive Landsat imagery needed for transportation planning. Noting USGS's free aerial imagery program for states, she asked whether something comparable could be done for municipal planners. Dr. Salomonson was sympathetic to this concern and suggested a two-tier pricing approach with time delay. On a point of clarification, it was noted that the USGS National Photography Program Database was inexpensive to use (not free) and in the public domain, but that it had been subsidized by taxpayers.

A question from Dr. Justice generated extensive discussion about possible congressional pressure behind the data buy option. Dr. Wende said that the commercial data buy option was included within the data specification approach in the off chance that a vendor could provide a ready-made product. He did not think that this was likely. The data specification approach, however, remained open to a variety other options. Dr. Beck reported that sources on Capitol Hill claimed that the pressure for a data buy originated from NASA Headquarters. Dr. Williams stated that the push for this did not originate at NASA-Goddard. Saying the Government got it right with Landsat 7, he did not want to return the program to the era of the big aerospace monopoly. Dr. Norman contended that commercial influence within Congress must have been behind the data buy strategy. From what he had heard at the workshop, he could not understand why industry was not lobbying for the current Landsat 7 model instead. Dr. Gabrynowicz replied that many people on the Hill might see industry as monolithic. The reality was that there were divergent players and interests in the commercial sector, just as there were many types of data with different applications. Another participant asked where the professional scientific associations were who should be lobbying on the LDCM. Mr. R.J. Thompson reported that Landsat7 did have vocal advocates but that the USGS itself had been criticized for its support of the mission.

Speaking from his position at NASA, Dr. Wende shifted the discussion to a consideration of NASA continuation in the Landsat program. Why, he asked, should a technologically mature endeavor going back three decades remain within the operational domain of a cutting-edge agency like NASA? If NASA could hand off the weather satellites to NOAA (the National Oceanic and Atmospheric Administration), could it not do something similar with Landsat? Mr. Byrnes thought the NOAA model was useful and attractive, but he could not guarantee that the USGS would ever become a "land NOAA" to provide a permanent home for the Landsat program.

At this point, Mr. Byrnes asked Dr. Wende to review the steps toward development of an RFP. He reiterated that the intent of the workshop was to help the Government make a smart procurement, to give flexibility to the data providers, and to share costs and rewards with partners. The cosponsors would benefit from public input into this process and the data specification. He thanked participants for the comments that they had provided during the meeting. Failure to resolve all the issues did not mean that the workshop had failed. Many ideas had been generated.

The next steps in the process included the preparation of a workshop summary, development of the draft and final RFPs, arrangement of additional workshops, and continued public comment and agency conversation with the greater Landsat community. He supplied participants with the following contact information for himself and Mr. Byrnes: cwende@hq.nas.gov (202) 358-0748 and rbyrnes@usgs.gov (703) 648-4787. He encouraged those present to participate in the EO 1 workshop scheduled for the following day.

There was also an announcement of another workshop sponsored by the Office of Earth Science on March 7 at the Omni Shoreham Hotel in Washington, DC. This meeting would address the new research strategy. A *CBD* announcement would appear within a week or so.

After thanking participants again for their attendance, Mr. Byrnes adjourned the plenary meeting. Breakout panel sessions were scheduled to convene after lunch.